How to power an off-grid telescope?

Comparative lifecycle assessment of renewable-based energy systems with batteries and hydrogen

HySchool Webinar September 4, 2023

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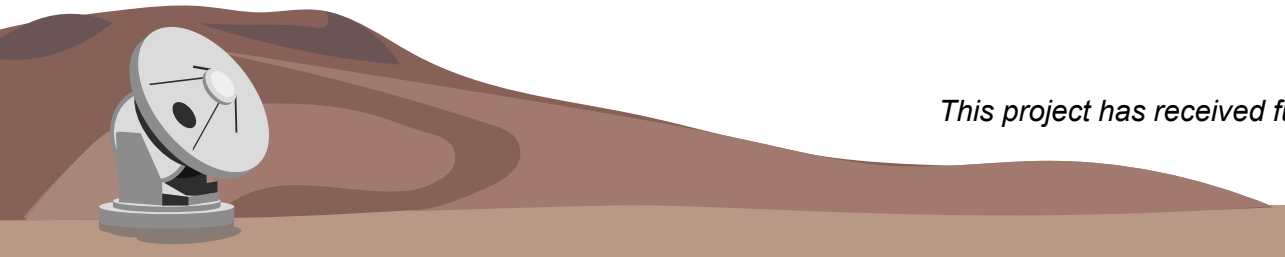
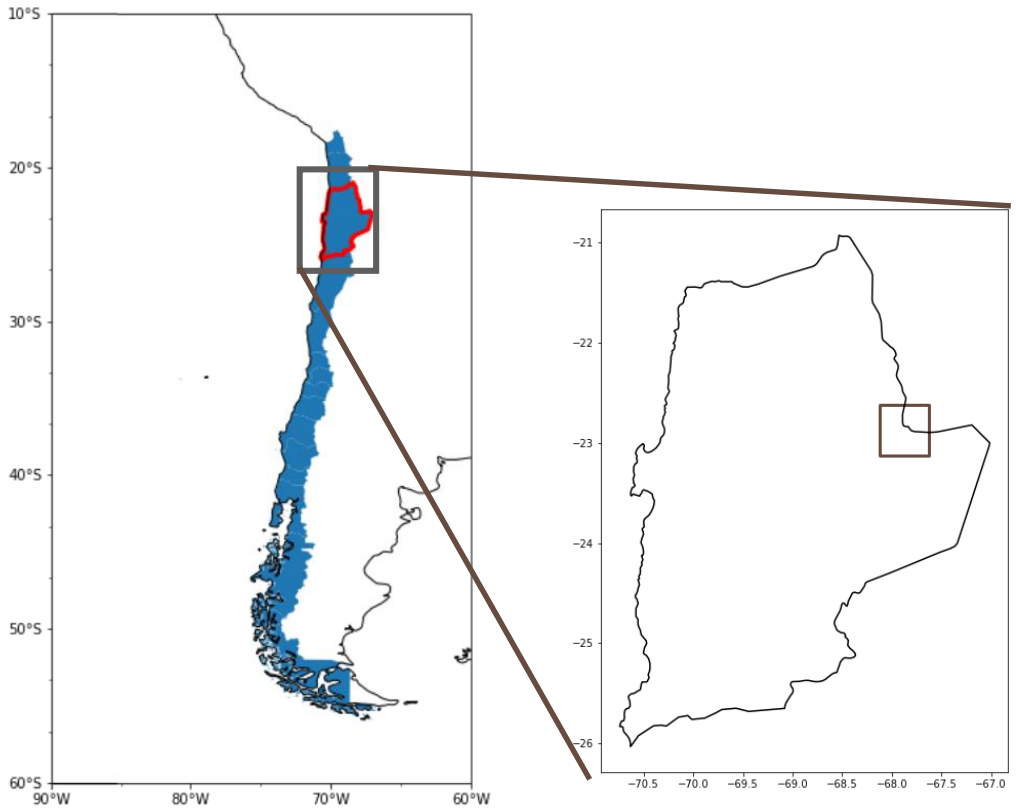


This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 951815.

How can we power an off-grid telescope?

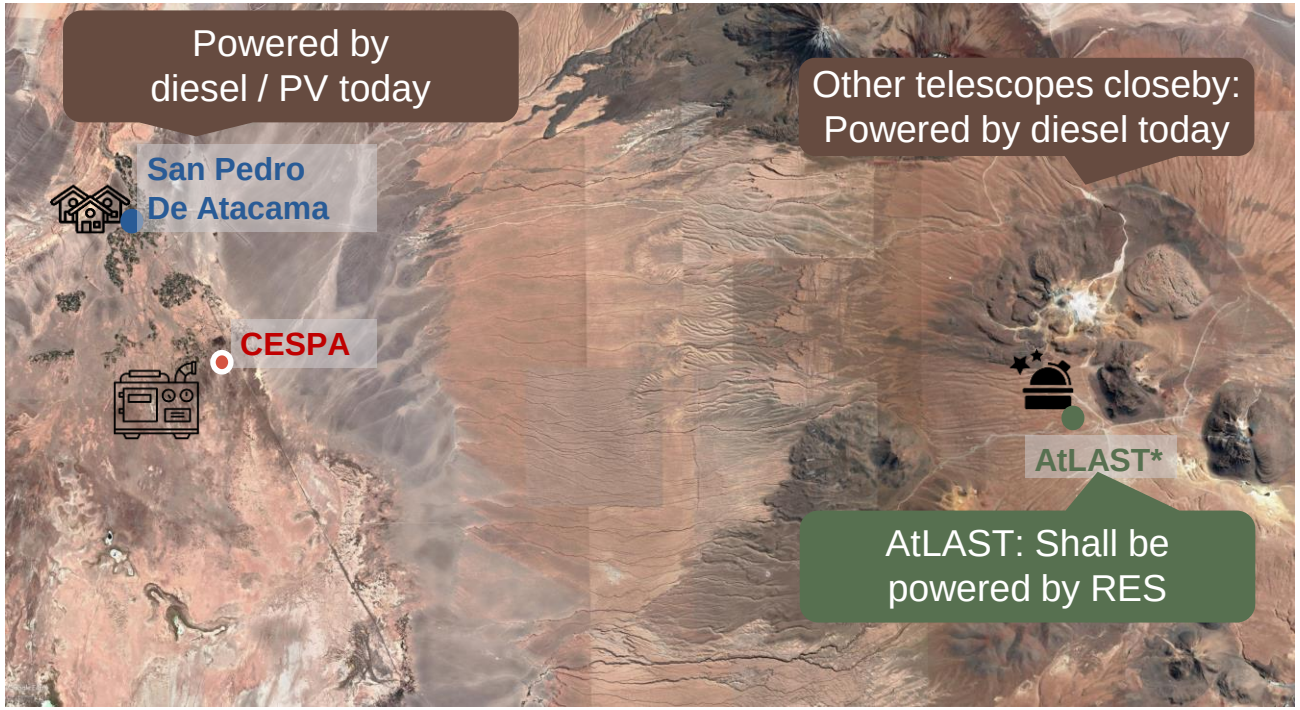
AtLAST:

- **1st telescope** to include **sustainable power** generation in design phase
- *funded under EU's Horizon* 2020 call *"Development and long-term sustainability of new pan-European research infrastructures"*



Remote location in the Atacama, Chile

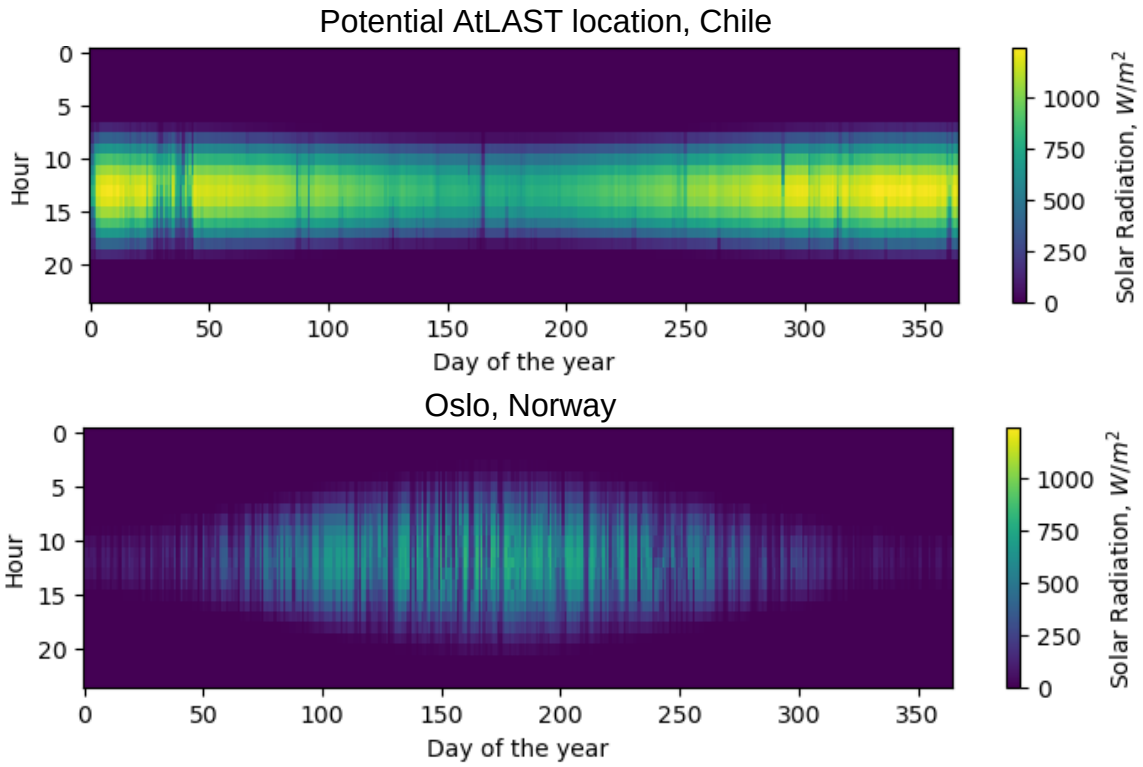
How can we power a remote telescope?

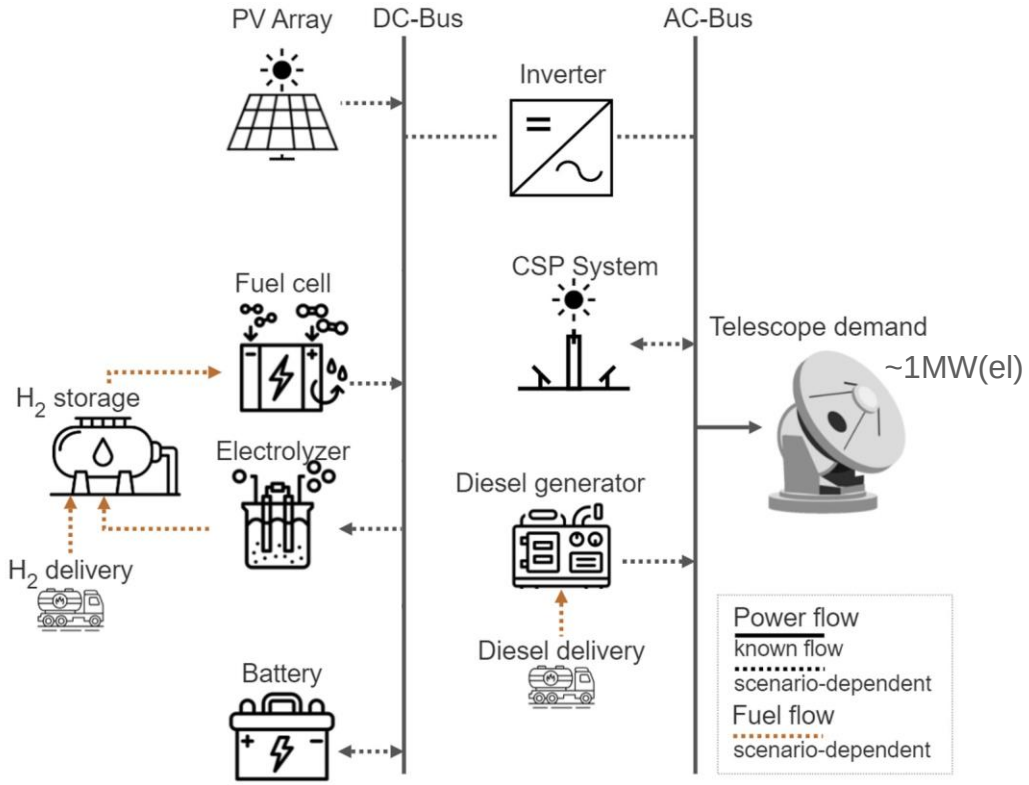


* Potential location for AtLAST, several options are investigated by the project.

Case study telescope

Designing a power system based on renewable energy sources

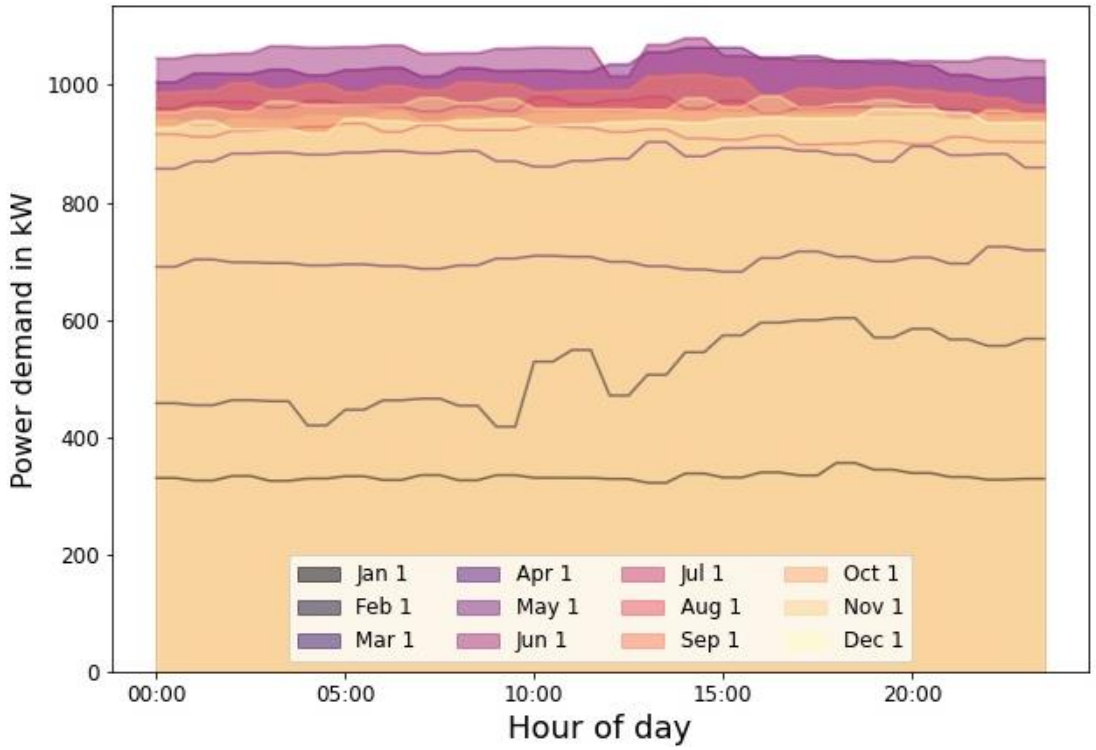


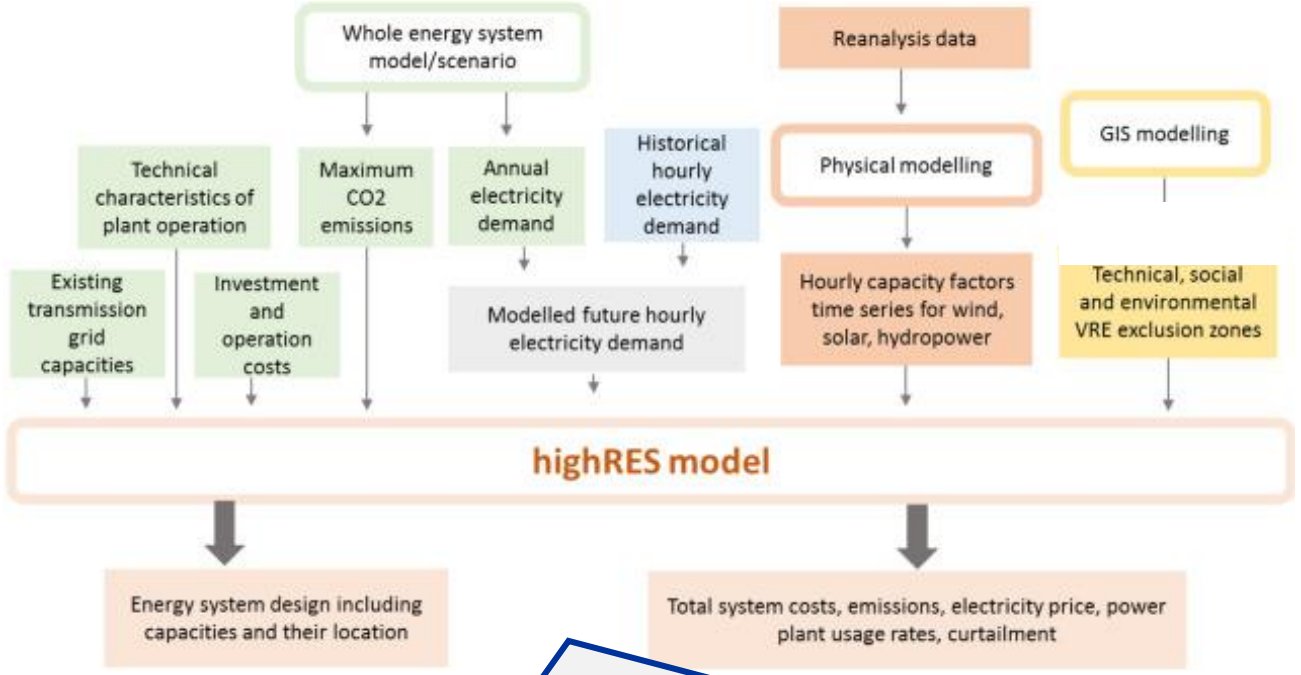


I. Viole et al., *"A* renewable power system for an off-grid sustainable telescope fueled by solar power, batteries *and green hydrogen," Energy,* p. 128570, Nov. 2023, doi: 10.1016/j.energy.2023.128570.

Techno-economical modeling

Estimating AtLAST's demand and optimizing the power system's size



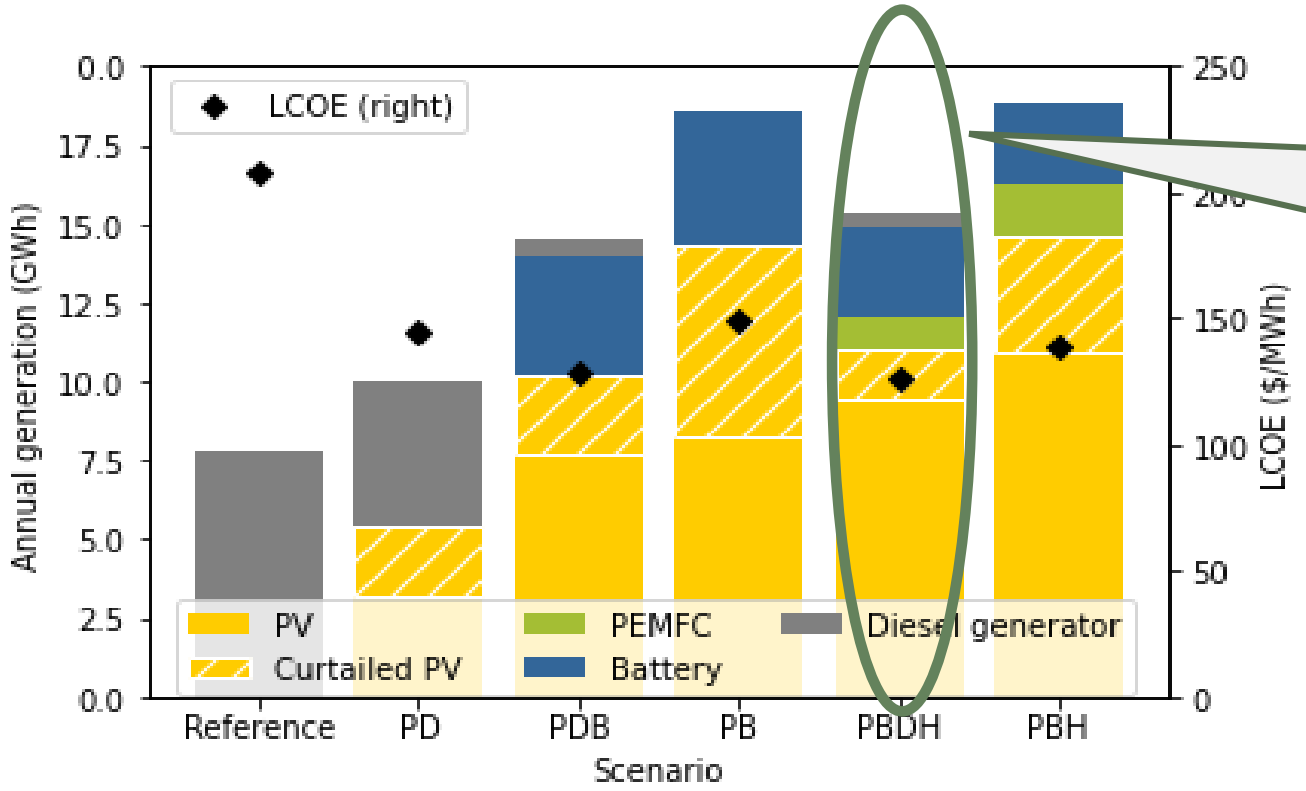


Adapted highRES to AtLAST case study

- Adding Hydrogen Storage in Compressed Gas or Metal Hydrides
- 2030 CAPEX estimations

Price & Zeyringer (2022): https://doi.org/10.1016/j.softx.2022.101003
Open source GAMS code: github.com/highRES-model/highRES-AtLAST

Systems mainly based on PV and hybrid energy storage cheapest
Techno-economical optimization for 2030



Cheapest scenario entails:

4.2MW$_{peak}$	Monocrystalline PV
0.6MW	Diesel generation
263kg	CG H_2 storage
15MWh	LFP battery

Reference: Diesel Generators
PD: PV & Diesel
PDB: PV, Diesel, LFP Batteries
PB: PV & Batteries
PDBH: PV, Diesel, Batteries, Hydrogen System
PDBH: PV, Batteries, Hydrogen

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Techno-economical modeling

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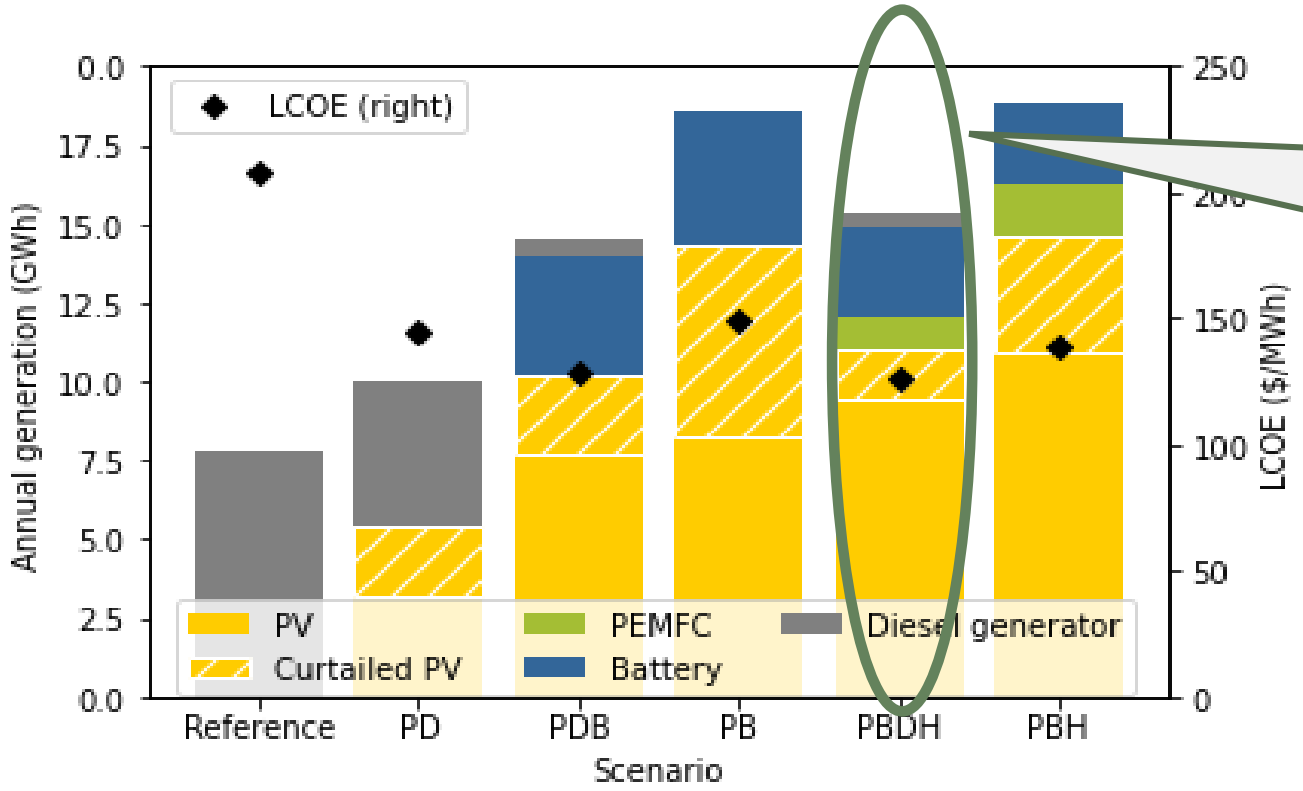

Cheapest scenario entails:

4.2MW$_{peak}$	Monocrystalline PV
0.6MW	Diesel generation
263kg	CG H_2 storage
15MWh	LFP battery

➢ Environmental impacts?

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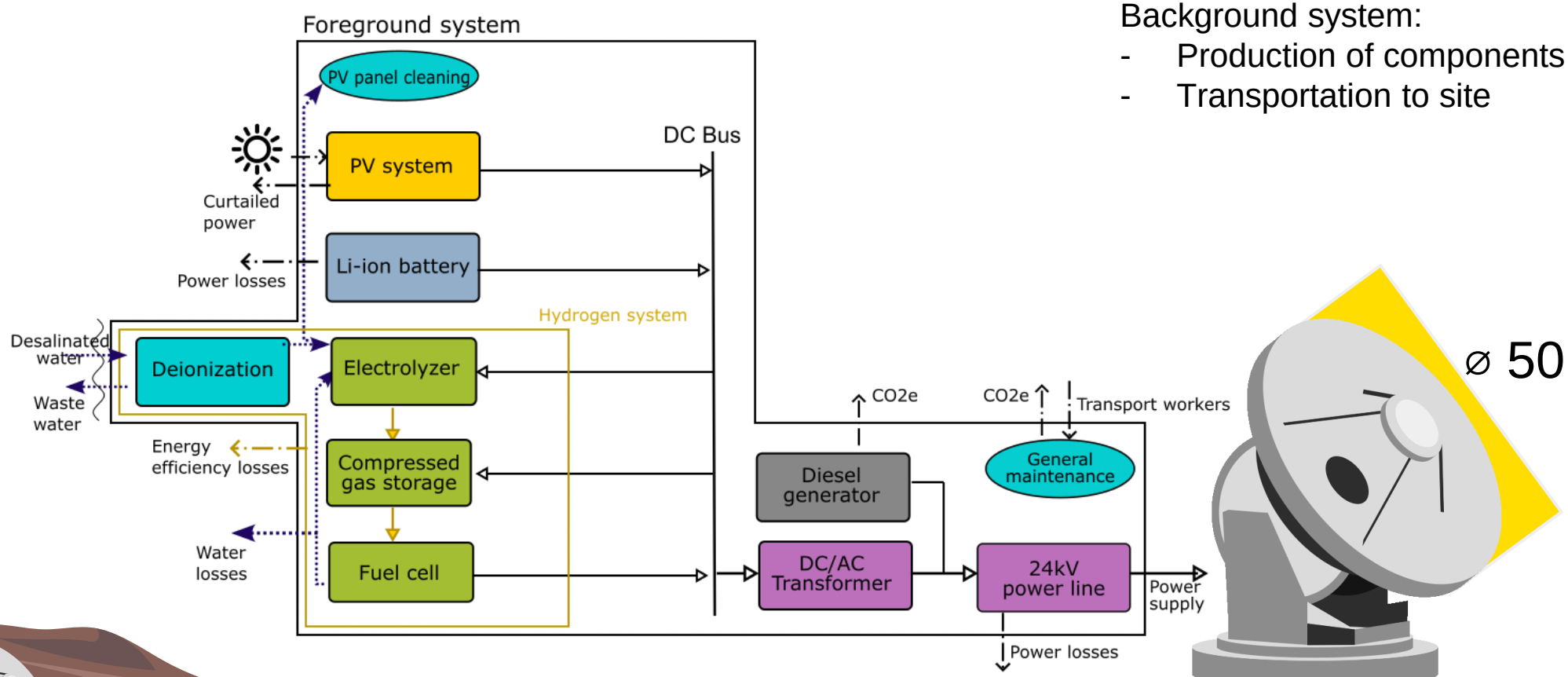
What's the environmental impact of these power systems?

Scoping of Life Cycle Assessment:



Background system:
- Production of components
- Transportation to site

This slide and following: I. Viole et al. (under review) "Sustainable Astronomy: A comparative Life Cycle Assessment of Off-grid Hybrid Energy Systems to supply large Telescopes," doi: 10.21203/rs.3.rs-3281965/v1.

Environmental modeling

Comparing low and zero carbon emissions of off-grid power system for AtLAST

Functional unit:

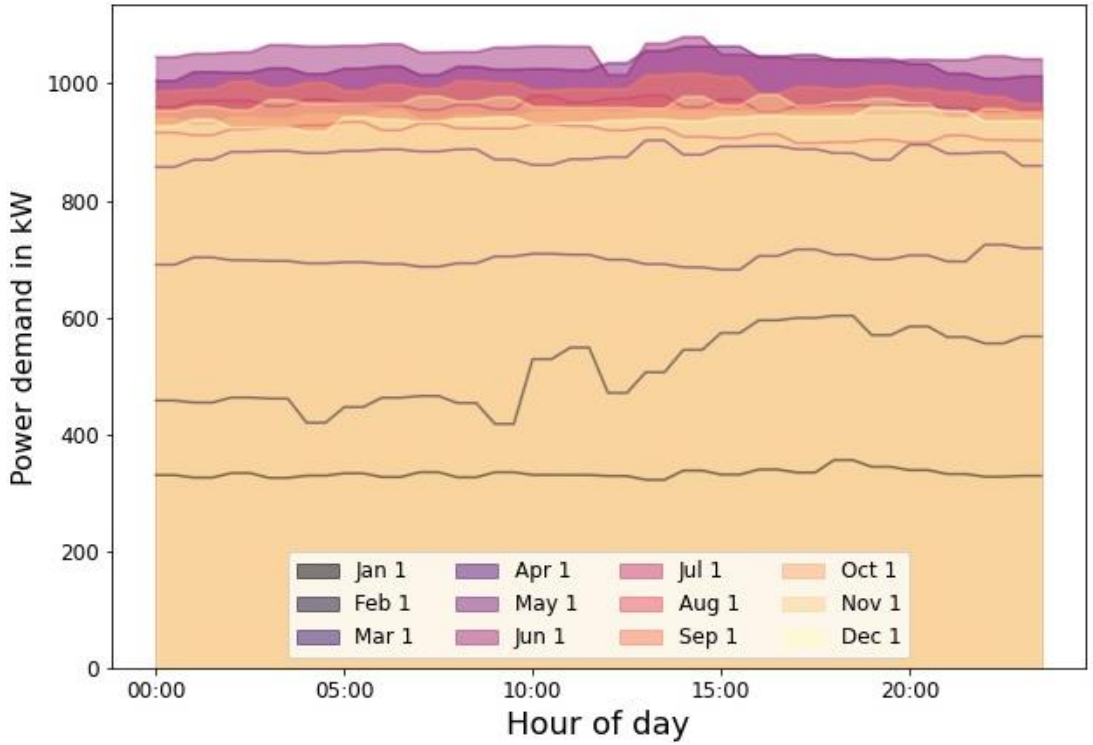
Deliver an annual power of 7.7GWh$_e$ *as per the telescope's estimated demand curve over a* lifetime of 25 years.

Temporal and areal scope:

- Power mixes in production countries for 2030.
- Transportation routes from production facilities to AtLAST.

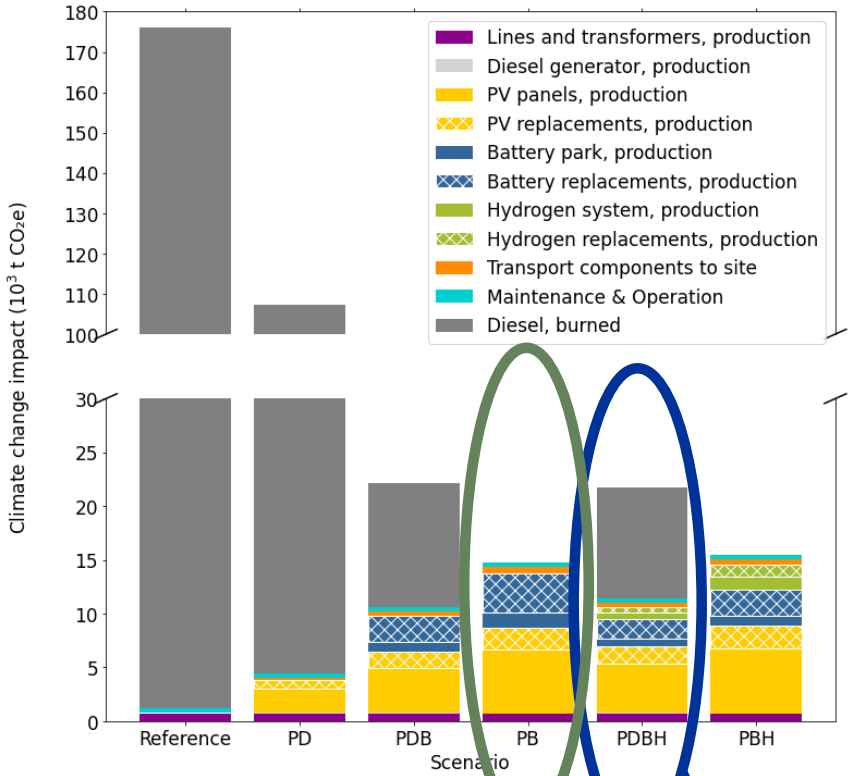
Environmental impact indicators:

- Climate change
- Mineral resource depletion
- Water use (Desert conditions)



Environmental impacts

Similar climate change impact of all-renewable & mostly renewable systems



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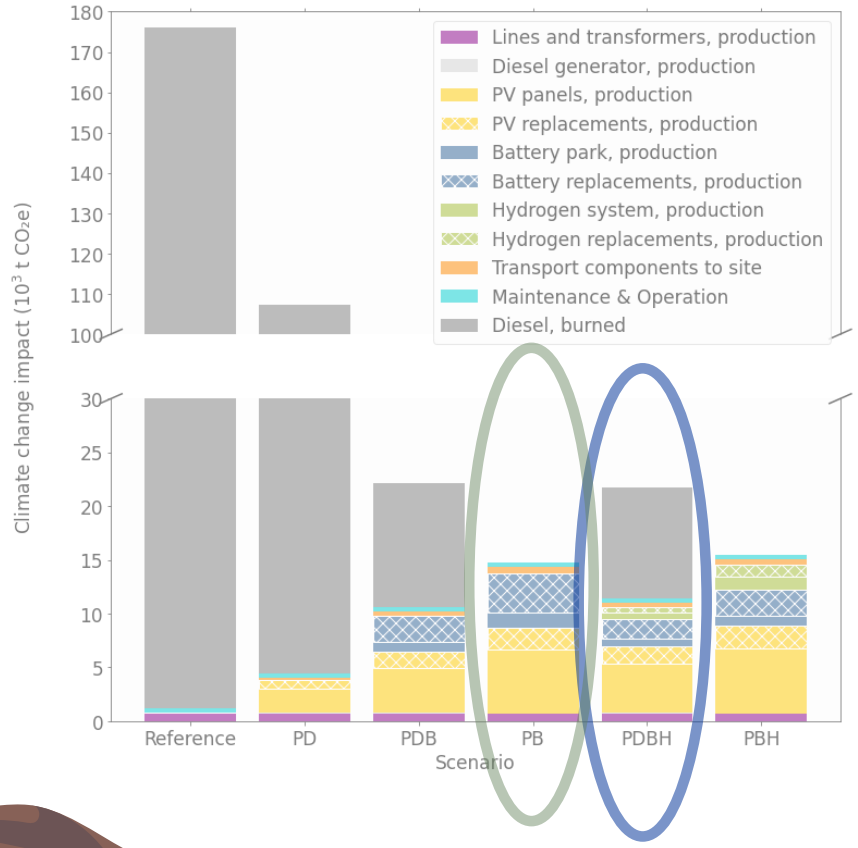
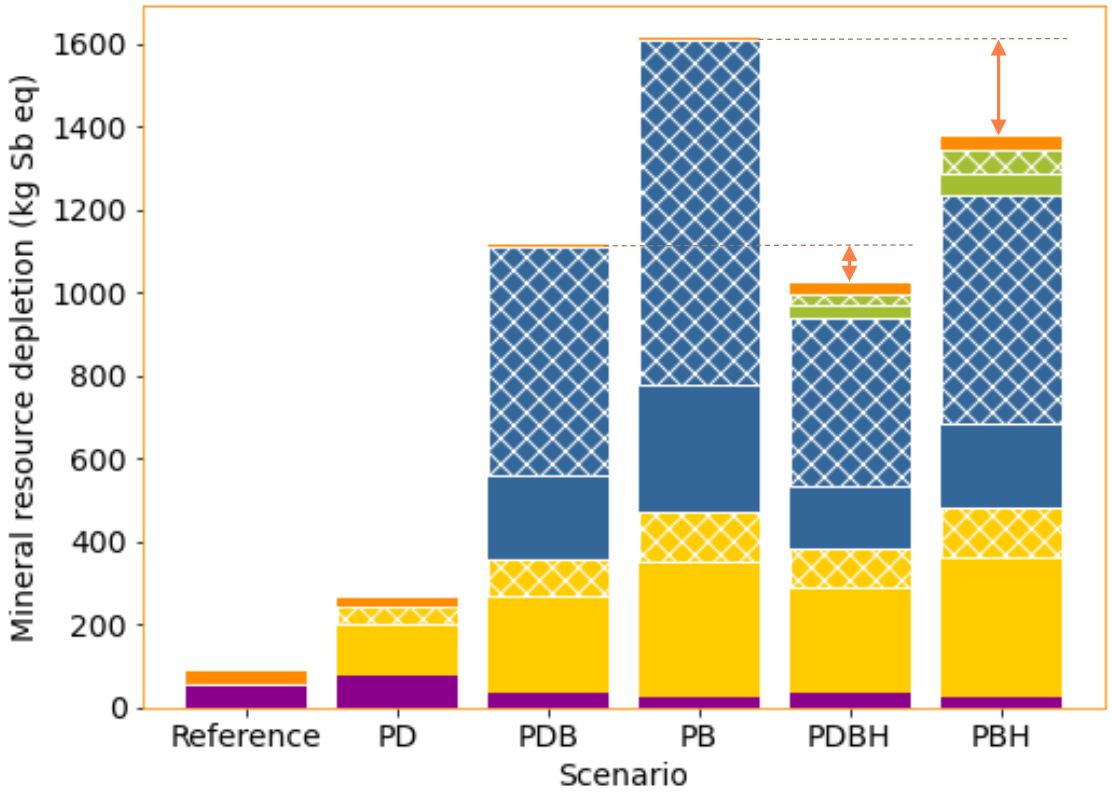
Environmental impacts

Systems with hydrogen & battery storage have lower mineral resource depletion compared to batter-ony storage





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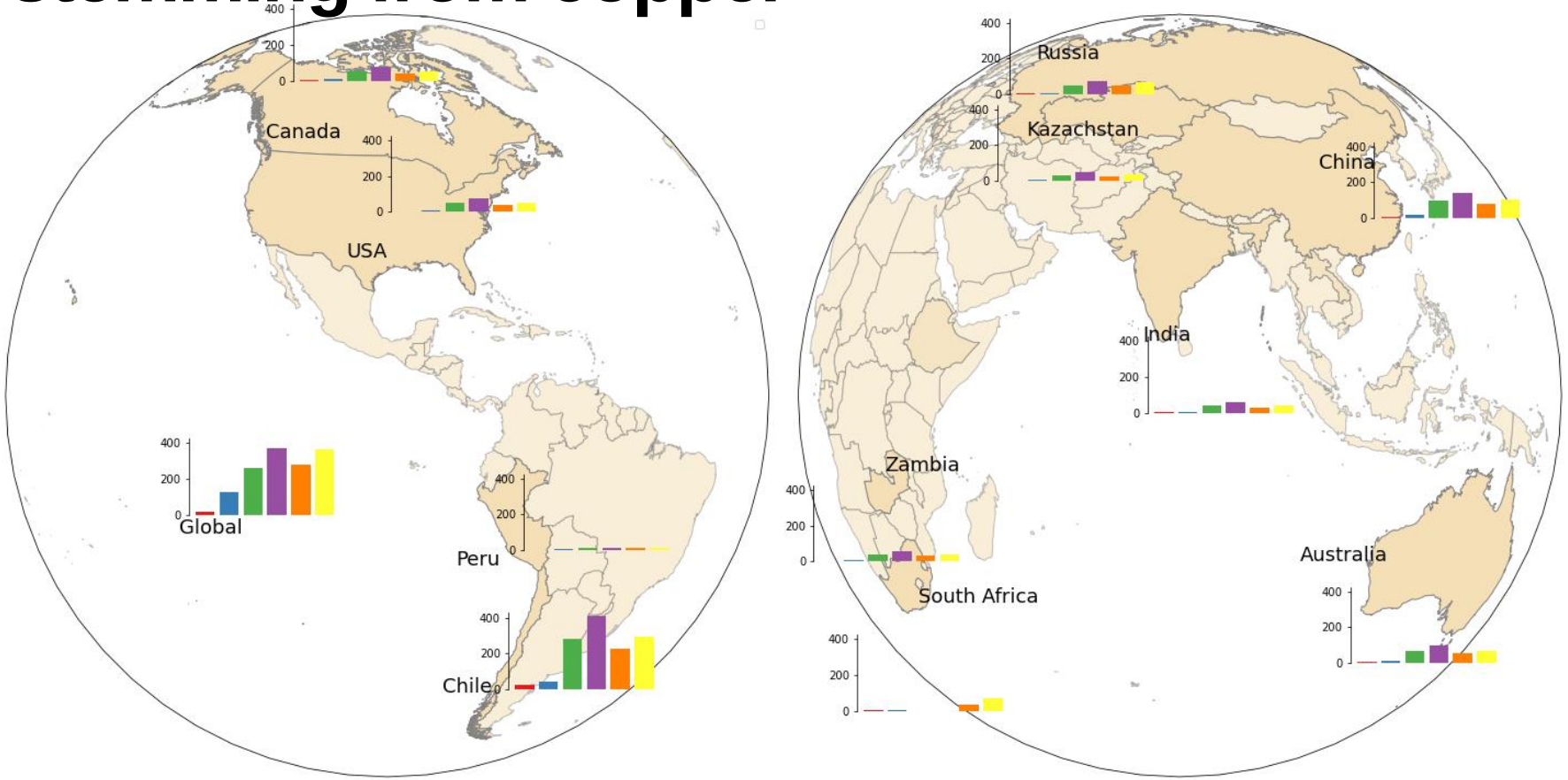
Global distribution of mineral use for energy system, mostly stemming from copper



Bars from left to right: Reference scenario, PD, PDB, PB, PDBH, PBH

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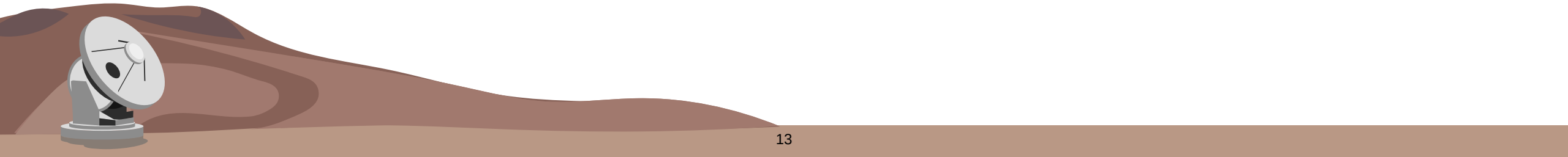
Conclusion

- Both LFP batteries & Hydrogen have different environmental advantages & disadvantages in the off-grid energy system
- But we need energy storage in general to decrease GHG impact



Read more on this research

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Isabelle Viole [*,1], Guillermo Valenzuela-Venegas [1], Marianne Zeyringer, Sabrina Sartori

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Sustainable Astronomy: A comparative Life Cycle Assessment of Off-grid Hybrid Energy Systems to supply large Telescopes

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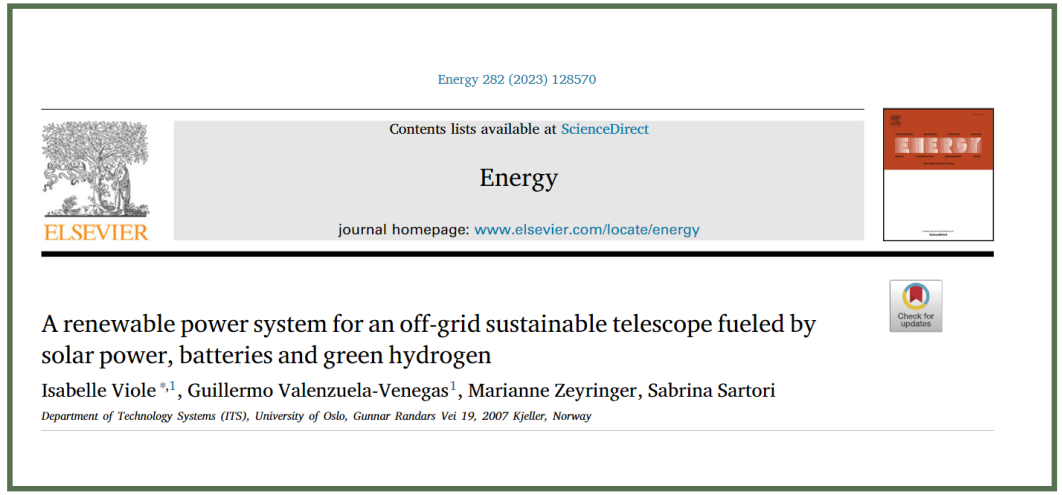

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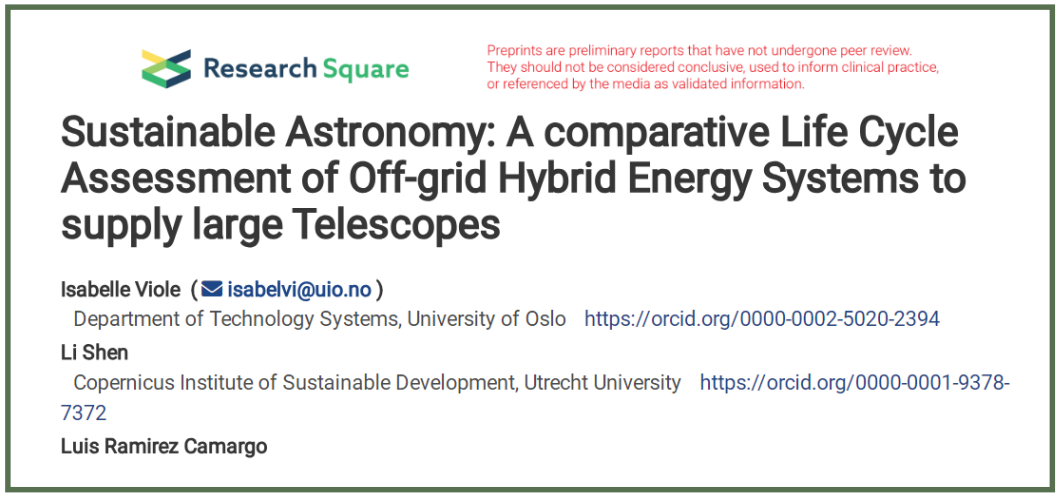

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Multi-objective optimization that minimizes both costs and climate change impact of the off-grid energy system for the telescope

Thanks!

Panoramic view of ESO's Atacama Pathfinder Experiment telescope (APEX).
Photo: ESO/B. Tafreshi (twanight.org)